March 16, 2001

SLOPE STABILITY ASSESSMENT

The following actions comprise the Slope Stability Assessment for the Lake Whatcom Landscape Planning Area. The Assessment, including a Sensitive Area Slope Stability Map, covers only DNR-managed lands within the Planning Area.

1) Reviewed the slope stability sections of the completed Lake Whatcom and Acme Watershed Analysis reports that cover most of the Planning Area.
2) Developed slope stability hazard maps for portions of the Planning Area not covered by Watershed Analysis reports. Slope stability mapping precepts consistent with the Lake Whatcom Watershed Analysis work were utilized.
3) Adjusted the mapped location of some stream channel-dependent landforms identified in the Lake Whatcom Watershed Analysis report.
4) Identified and mapped slopes steeper than 70% using DNR topographic maps.
5) Developed a composite (actions 2, 3 and 4, above) Slope Stability Sensitive Area Map.
6) Drafted definitions for unstable slopes and potentially unstable slopes.

DNR recently completed a topographic mapping project for the Lake Whatcom Planning Area. The resultant topographic maps are relatively large-scale (1" = 400') and have 20-foot contour intervals. (Only 1" = 2000' -scale topographic maps were available when the Lake Whatcom and Acme Watershed Analyses were completed.) Since topography is a significant factor in slope stability hazard determination, these new maps were used in making the slope stability mapping revisions described in this Assessment.

1) Slope stability information review

Text and map information comprising the Lake Whatcom Watershed Analysis report (June 1997) and the Acme Watershed Analysis report (May 1999) collectively present a relatively thorough evaluation of slope stability conditions on most of the Lake Whatcom Landscape Planning Area. The Cain Lake basin in the southwest part of the Planning Area and a "fringe" of land along the west side of Lookout Mountain are not covered by Watershed Analysis reports, but conditions in these two areas are similar to adjacent portions of the Lake Whatcom Watershed Analysis Unit.

The slope stability sections of the Lake Whatcom and Acme Watershed Analysis reports were reviewed. The findings of published literature pertinent to slope stability issues in the Planning Area were incorporated into the Watershed Analysis reports. Within the framework of Washington's Watershed Analysis procedures, the text, landslide inventories, slope stability map descriptions, and assigned landslide hazard ratings contained in these reports accurately reflect slope stability conditions in the Planning Area. Slope stability hazard area descriptions and maps (Appendices A and B) developed as part of the Watershed Analysis reports delineate areas with unique geology, landform and slope conditions where historical evidence suggested that landslides could be triggered by specific forest management activities. However, on-the-ground accuracy of the slope stability hazard maps is subject to the potential problems inherent in all such maps, i.e., subjective interpretation of remotely sensed information, and the transfer of that

information to relatively small-scale maps. The review of slope stability hazard maps in the Lake Whatcom Watershed Analysis report indicated a need to adjust the location of some high hazard areas associated with incised stream channels.

2) Slope stability mapping of areas not covered by Watershed Analysis

The Cain Lake basin in the southwest part of the Planning Area and a "fringe" of land along the west side of Lookout Mountain are not covered by Watershed Analysis reports. However, both of these areas border on and have landforms, geology and topography similar to terrain covered by the Lake Whatcom Watershed Analysis report. In fact, landslides in the Cain Lake basin were mapped during the Lake Whatcom Watershed Analysis, but slope stability hazard maps were not completed. As part of this Assessment, a slope stability conditions were mapped for the Cain Lake basin and the west side of Lookout Mountain using Watershed Analysis precepts. Slope stability hazard area descriptions in the Lake Whatcom Watershed Analysis, existing information on landslide locations, aerial photo interpretation, and DNR topographic maps were used in the mapping process. These high hazard areas are included on the composite Slope Stability Sensitive Area Map developed as part of this Assessment.

3) Adjustments to landslide hazard area Watershed Analysis maps

Comparisons of landslide hazard maps produced for the Lake Whatcom Watershed Analysis report and DNR topographic maps indicated some discrepancies. Specifically, the mapped location of some high hazard, stream channel-dependent landforms did not coincide with channel locations on the DNR topographic maps. A review of aerial photos revealed that the actual location of several stream channels – and the extent of associated inner gorge/headwall/bedrock hollow landforms – are more accurately reflected on DNR topographic maps than on maps available when the Lake Whatcom Watershed Analysis report was completed. Adjustments (additions and deletions) to two landslide hazard areas shown on the Lake Whatcom Watershed Analysis report maps were made based on aerial photo interpretation, DNR topographic maps and local knowledge. The adjustments appear on the composite Slope Stability Sensitive Area Map developed as part of this Assessment.

4) Slopes steeper than 70 %

Numerous site-specific factors influence slope stability; however, slope gradient (gravity) plays a significant role – especially on steep slopes. Generally, on slopes steeper than about 70%, deep soils that are poorly bound to underlying geologic materials or soils with little root reinforcement are susceptible to landsliding.

The high and moderate slope stability hazard areas mapped for the Watershed Analysis reports encompass most slopes steeper than 70%, and a very high percentage of the identified landslide sites. For example, in the Lake Whatcom Watershed Analysis Unit, 97½ % of identified landslides occurred in hazard areas identified by the Watershed Analysis report. The addition of all slopes in the Planning Area steeper than 70% on the DNR topographic maps increases the acreage identified through the Watershed Analysis process as being potentially unstable. These steep slopes are shown on the Slope Stability Sensitive Area Map developed as part of this Assessment.

5) Slope Stability Sensitive Area Map

A Slope Stability Sensitive Area Map (Appendix C) was developed for the Planning Area. It is intended to include both unstable slopes and potentially unstable slopes. The map is a composite of: 1) high and moderate slope stability hazard areas identified by the Lake Whatcom and Acme Watershed Analysis reports; 2) adjustments to portions of the high hazard slope stability map created by Watershed Analysis reports based on aerial photo interpretation, slope gradients indicated on DNR topographic map, or personal knowledge of local conditions; 3) slopes indicated to be steeper than 70% on the DNR topographic map; and, 4) high slope stability hazard areas mapped as part of this Assessment in the Cain Lake basin and on the west side of Lookout Mountain.

The Slope Stability Sensitive Area Map is a compilation of the best available information regarding slope stability conditions on the Planning Area. Its level of accuracy is reasonable and sufficient for planning purposes. However, the map no doubt contains errors of inclusion and exclusion. That is, the specific location of stable, potentially unstable, and unstable slopes are probably not represented entirely accurately on the map. For this reason the definitions of unstable and potentially unstable slopes (as opposed to map locations) are the determining criteria for field identification.

6) Definitions of unstable slopes and potentially unstable slopes

The attempt to distinguish between unstable slopes and potentially unstable slopes was undertaken because legislation (Engrossed Second Substitute Senate Bill 6731) directing this planning effort implies that there is a difference, and different management practices are prescribed. In fact, it is not always possible to distinguish between unstable slopes and potentially unstable slopes. (The full range of possible slope stability conditions is best envisioned as a continuum rather than a series of discrete pigeonholes.) Positive identification of potentially unstable slopes is often difficult because past slope stability conditions may not accurately foretell future conditions. Slope stability determinations are subjective processes involving the application of both "science" and professional judgment.

Unstable slopes exhibit evidence of recent (up to decades), persistent or sporadic mass movement. Instability may be related to, or independent of, forest management activities.

Potentially unstable slopes are:

- over-steepened areas (critical gradient varies with site conditions)
- inner gorges
- convergent headwalls
- bedrock hollows > 70%
- toes and scarps (> 65%) of deep-seated landslides
- valley walls at outer edges of stream meanders
- areas that exhibit a combination of "**indicators**" which, when considered cumulatively, indicate potential for landsliding

Potentially unstable slopes do not exhibit evidence of recent landsliding.

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Example **"indicators**" of landslide potential

- new or abandon stream channels; channels angled across slope
- sag ponds
- wet slopes showing springs, groundwater seepage, wet-site vegetation
- linear, arcuate or other patterns of disturbed vegetation
- jack-strawed, pistol-butted, tilted, or split trees
- old landslide scars
- very steep slopes
- ground surface tension cracks; small scarps (cat-steps)
- hummocky ground
- cracked, sagged, slumped roadways
- debris piled against uphill side of trees
- freshly exposed bedrock surfaces or cracks

Application of Slope Stability Assessment Information

Proposed management activities within areas delineated on the Slope Stability Sensitive Area Map should be reviewed by a slope stability specialist. The specialist should first determine whether the proposed activity involves, or likely could affect, unstable or potentially unstable slopes. (The definition of unstable and potentially unstable slopes – as opposed to map location – is the determining criteria for field identification.) If unstable or potentially unstable slopes are present, the likely effects of the proposed activity need to be specifically identified. Both site-specific slope stability-related conditions and details of the proposed activity need to be considered in determining its likely effects, and whether (or to what degree) the effects can be mitigated. These decisions should be made through an interactive process involving the slope stability specialist, the timber harvest engineer and/or road engineer, and other appropriate specialists.

The Slope Stability Sensitive Area Map and the slope stability evaluation procedures suggested in this Assessment do not supersede existing Watershed Analysis reports covering the Lake Whatcom Landscape Planning Area. Proposed management activities in the Planning Area will continue to be regulated by Forest Practices Rules and applicable Watershed Analysis Prescriptions.

Appendices

Appendix A Descriptions and regulatory Prescriptions for areas within Lake Whatcom and Acme Watershed Analysis Units rated as "high" and "moderate" landslide hazard.

Appendix B Map G-1, High and Moderate Hazard Mass Wasting Map Units for the Lake Whatcom Planning Area (Lake Whatcom and Acme Watershed Analysis Units).

Appendix C Map G-2, Slope Stability Sensitive Area Map.

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Appendix A

LAKE WHATCOM WATERSHED ANALYSIS PRESCRIPTIONS

OVERVIEW

DEFINITIONS

Signs of instability

- micro-landform features such as tension cracks, scarps, hummocky surface, convergent areas
- conifer trees with sweep, lean, pistol butt
- springs/seeps, soft or wet soils
- wet-site vegetation

(This list is not intended to be all-inclusive nor is it intended that the presence of any one - depending on severity - constitutes an unstable slope)

Headwalls:

Also known as zero-order basins or channel heads, these areas deliver water (typically sub-surface) to defined channels where surface water flows and bank incision begins. They are common just above the start of headwater channels, but can occur anywhere along the channel on steep sideslopes.

Bedrock hollows:

Linear topographic depressions that concentrate sub-surface water and colluvium (soil, rock fragments, organic material). Vegetation is the key factor for maintaining the integrity of hollows because roots can anchor the soil mass to bedrock and provide soil cohesion by binding individual particles. Debris torrents commonly begin in these topographic features when located on steep slopes.

Inner gorges:

Small, steep-sided canyon formed by stream incision. Slopes in this canyon extend upward some distance to a slope break.

Deliverability (from Watershed Analysis manual glossary)

Likelihood that, as a result of one or more forst practices or by cumulative effects, a material amount of wood, water, sediment, or energy will be delivered to fish habitat, streams, or capital improvements; three conditions must all be satisfied: 1) an impact is likely to occur; 2) the magnitude or size of the impact is sufficient to have a significant effect on the resource characteristic(s); and (3) the impact is likely to be delivered to a stream segment with a vulnerable resource.

Specialist involvement

Specialist involvement will include a geotechnical report which addresses the following topics:

(1) a detailed map showing harvest boundaries and location of sensitive landforms/sites;
(2) on-site delineation of the boundaries and locations of sensitive landforms/sites;
(3) a statement regarding the adequacy of harvest plans for maintaining slope stability;
(4) verification that the final harvest plan is in accordance with the geotechnical recommendations.

LAKE WHATCOM WATERSHED ANALYSIS UNIT

MASS WASTING MAP UNIT**:** 1B

DESCRIPTION: Headscarps with slopes 80%-100% and toes with slopes greater than 20% (generally 60-70%) at the perimeter of large, ancient and dormant deep-seated landslide complexes in slump-earthflow terrain.

HAZARD CALL**:** MODERATE

PRESCRIPTION**:**

Timber Harvest:

No timber harvest on slopes greater than 60% with significant signs of instability (see definitions in overview) with potential for delivery to stream channels and/or identified public works.

Road Construction:

Slopes greater than 50%:

No road construction.

Slopes less than 50%:

(1) temporary roads shall be constructed and inactivated between May 1st and October 15th;

(2) permanent road cutbanks shall be buttressed with appropriate materials that will prevent slope failure. (3) cross drain spacing shall meet or exceed the recommendations established in the Forest Practices Board Manual page M-21 on all roads.

MASS WASTING MAP UNIT**:** 1C

DESCRIPTION**:** The banks and adjacent side-slopes (50%, generally 70-90%) of steep gradient, incised (distance from channel bed to slope break is. 10 feet) stream channels that drain the large, ancient and dormant deep-seated landslide complexes and slump-earthflow terrain.

HAZARD CALL**:** HIGH

PRESCRIPTION**:**

Timber Harvest:

(1) No timber harvest in the MWMU, however, cable yarding corridors are permissible provided no more than 20% of the length of the leave area is affected;
(2) Full suspension through the MWMU is required unless methods proven to avoid soil disturbance are employed.

Road Construction:

All road construction shall meet the following standards:

(1) Stream crossing structures shall be bridges with keyed footings or culverts with dipped, keyed, competent, solid rock fills, or fords†; these structures shall be designed to accommodate the 100-year flow;
(2) All roads shall be designed to minimize road length within the MWMU;
(3) All road and stream crossing structures shall be slope-staked in the field;
(4) Construction shall be supervised on site by the designer or an equally or more qualified specialist;
(5) Design drawings and calculations for the road and all crossing structures are required and shall be included with the Forest Practice Application;
(6) No sidecast construction will be permitted within the MWMU;
(7) Ditch water and road surface drainage shall remain in the drainage of origination;
(8) Ditch water and road surface drainage directed into the MWMU shall be minimized;
(9) Construction shall proceed only during periods of low soil moisture.

† - use of native fill material is permissible under the following conditions:

(1) construction and use is limited to May 1st through October 15th;
(2) removal of crossing is to be done promptly upon completion of operation but no later than October 15th.

Road Maintenance:

Active and inactive roads within this MWMU shall have a road maintenance plan based on the specifications in WAC-222-24-050.

MASS WASTING MAP UNIT**:** 2

DESCRIPTION**:** Headwalls and inner gorges greater than 70% , uninterrupted slopes greater than 50% above inner gorges, and small deep seated slumps with slopes that are generally greater than 40%, but may be as gentle as 20%. This unit is in phyllite and includes Blue Canyon, its tributaries, and South Creek. Materials in this unit are soil and colluvium derived from deeply weathered or pervasively fractured Darrington Phyllite, and from glacial sediment.

HAZARD CALL: HIGH

PRESCRIPTION:

Timber Harvest:

On slopes greater than 70%:

No timber harvest.

On slopes less than 70%:

A geotechnical specialist will visit the harvest site and identify deep seat-landslides within the unit.

Specialist involvement (see definition in overview) will include a geotechnical report which addresses the following topics:
(1) a detailed map showing harvest boundaries and location of actively moving deep seated features;
(2) on-site delineation of the boundaries and locations of actively moving deep seated features.

No timber harvest on recent (within the past 60 years) or actively moving deep-seated features.

Road Construction:

No road construction.

MASS WASTING MAP UNIT**:** 4

DESCRIPTION: Planar and concave slopes greater than 70 percent associated with headwalls, bedrock hollows, inner gorges; and steep, uninterrupted slopes greater than 50 percent adjacent to streams and/or identified public works. Materials in this unit are bedrock and soils derived from the Chuckanut Formation, thick colluvium, and glacial till. Includes upper Blue Canyon.

HAZARD CALL: HIGH

PRESCRIPTION:

Timber Harvest:

Inner Gorges (>70%):

No harvest. Full suspension of logs yarded through inner gorge is required.

Headwalls and Bedrock Hollows (>70%):

Where landform is not deliverable and where indicators of potential instability are not present: Standard forest practice rules apply.

Where landform is deliverable and where indicators of potential instability are present: No harvest.

Where landform is deliverable or where indicators of potential instability are present: No harvest unless supported by specialist involvement.

Uninterrupted slopes >50% above streams, inner gorge slope breaks, and/or identified public works:

With no indicators of potential instability[1] and on slopes 50-70%: Standard forest practice rules apply.

With no indicators of potential instability and on slopes >70%: Within 100 feet (slope distance) of stream, inner gorge slope break, and/or identified public works, no harvest can occur unless supported by specialist involvement.

With indicators of potential instability[1] present: No harvest within 100 feet (slope distance) of stream, inner gorge slope break, and/or identified public works.

Beyond 100 feet (slope distance), no harvest unless supported by specialist involvement[1]

With evidence of recent (60 years) slope failures: No timber harvest.

Note:(applies to all landforms listed above): Minimal tree removal may be permitted to provide corridors for full suspension skyline yarding provided that skyline yarding would avoid otherwise necessary road construction. Corridor placement shall result in minimal cutting of and/or damage to trees; corridor location shall be free of significant signs of instability.

Road Construction:

Road construction shall, in most instances, avoid this MWMU. The exception is when a properly designed and constructed road may provide greater environmental protection than other alternatives. In such cases, road construction may be permitted provided the location does not exhibit significant signs of instability (see list above). The proponent shall demonstrate the stability of the location and design through a structured, reproducible, and defensible approach. Such roads would preferably be of a temporary nature, but it is recognized that permanent access for management activities will be necessary on some road systems.

All road construction shall meet the following standards:

(1) Stream crossing structures shall be bridges with keyed footings or culverts with dipped, keyed, competent, solid rock fills, or fords†; these structures shall be designed to accommodate the 100-year flow;
(2) All roads shall be designed to minimize road length within the MWMU;
(3) All road and stream crossing structures shall be slope-staked in the field;
(4) Construction shall be supervised on site by the designer or an equally or more qualified specialist;
(5) Design drawings and calculations for the road and all crossing structures are required and shall be included with the Forest Practice Application;
(6) No sidecast construction will be permitted within the MWMU;
(7) Ditch water and road surface drainage shall remain in the drainage of origination.
(8) Ditch water and road surface drainage directed into the MWMU shall be minimized;
(9) Construction shall proceed only during periods of low soil moisture.

† - use of native fill material is permissible under the following conditions:

(1) construction and use is limited to May 1st through October 15th;
(2) removal of crossing is to be done promptly upon completion of operation but no later than October 15th.

Road Maintenance:

Active and inactive roads within this MWMU shall have a road maintenance plan based on the specifications in WAC-222-24-050.

ACME WATERSHED ANALYSIS PRESCRIPTIONS

Insert paper copies of pages 1-11 of "Acme Watershed Analysis Prescriptions,Exhibit G, Final Prescriptions" as pages G-13 to G-22.